BUILDING ON THE PAST - LOOKING TO THE FUTURE: A FOCUS ON PAYLOAD SAFETY

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ABSTRACT

The history of the space industry stretches far and above lunar landings to the construction of the International Space Station. For years, humans have sought to understand the nature of the universe. As society grows in knowledge and curiosity of space, the focus of maintaining the safety of the crew and vehicle habitability is of utmost importance to the National Aeronautics and Space Administration (NASA) community. Through the years, Payload Safety has developed not only as a Panel, but also as part of the NASA community, striving to enhance the efficiency and understanding of how business should be conducted as more International Partners become involved. This is the first in a series of papers and presentations in what is hoped to be an annual update that provides continuous challenges and lessons learned in the areas of communication, safety requirements and processes and other areas which have been vital to the Payload Safety Review Panel (PSRP).

1. BACKGROUND

Manned Space Flight has a rich and vibrant history, full of great successes interspersed with set backs. Through manned space flight, humans have sought to learn much about both the universe and the microgravity environment of space and its effects upon materials and living organisms through experimentation and research. The National Aeronautics and Space Administration (NASA) established the Payload Safety Review Panel (PSRP) as both a panel and a format by which experiments, deemed Payloads, are reviewed for Space Flight Safety. A great deal of knowledge regarding hardware safety and process improvements has been gleaned by the PSRP through the various payloads that have been assessed for safety and their subsequent operation in space.

The recent additions of the European Space Agency (ESA) Columbus Orbiting Laboratory (COL) (launched on STS-122/1E) and the Japan Aerospace Exploration Agency (JAXA) Japanese Experiment Module (JEM) or KIBO (launched on STS-123/1J/A) to the International Space Station (ISS) mark significant accomplishments in Manned Space Flight as the ISS has become a truly international endeavor with participation from Americans, Russians, Europeans, Japanese, and Canadians. The testing of Ares-1 in 2009 and the STS-133/ULF5 mission in 2010 will also mark milestones with testing the new Constellation vehicle and retiring the Space Shuttle vehicle. Changes are inevitable with these milestones. In looking to and planning for the future, we should build on and learn from the past.

To that aim, a team of contract Safety and Mission Assurance (S&MA) Payload Safety Engineers (PSEs), PSE Team and Technical Leads, and a NASA PSRP Chairman set out to review key lessons learned in Payload Safety and the PSRP and to assess how specific and strategic planning will ensure success for future endeavors. We focused on three main areas in reviewing past experiences and planning for the future: communication, safety requirements, and processes. This paper highlights concerns within the topic areas, provides information and examples, and highlights plans for the future of Payload Safety in space exploration and experimentation.

1.1. NASA PSRP

Multiple safety panels, developed intentionally with different specific functions exist within NASA. This paper focuses on NASA's PSRP.

Chartered by NASA in the 1970s, the PSRP began conducting reviews of payload flight hardware or Flight Safety Reviews (FSRs) in 1979 in support of the Space Shuttle Program (SSP). Today, the PSRP supports both the Space Shuttle Program and the ISS Program and will be supporting NASA's newest program, the Constellation/Exploration Program, in the future.

Supporting two Programs results in a very full calendar for the PSRP and its technical support personnel. In Fiscal Year (delineated as October 1, 2007-September 30, 2008) 2008 (FY08), the PSRP conducted approximately 158 formal (full-panel reviews/discussions) FSRs and 281 informal (Outside-

Of-Board (OOB) or partial panel reviews/discussions and Working Groups (WGs)).

The PSRP is comprised of approximately twelve members representing key NASA Directorates (divisions) and the Space Shuttle and ISS vehicles, with meetings conducted by the Chairperson. Assisting the core panel members are numerous technical/discipline-based personnel (most of whom are organizationally part of NASA's Engineering Directorate). There is also an Executive Officer from the S&MA Directorate that seeks to maintain the consistency of the panel and interpretation of safety requirements. The PSRP is tasked to perform the following functions on the behalf of the Space Shuttle Program (SSP) and ISS Program Managers [1][2]:

- Assist Payload Organizations (POs) in the interpretation of safety requirements and provide recommendations for implementation and/or interpretation,
- Conduct FSRs as appropriate during various phases of hardware design/development,
- Evaluate modifications to hardware that either affect a safety critical subsystem or create a potential hazard to the vehicle or crew,
- Evaluate safety analyses, safety reports, and non-compliant conditions,
- Evaluate safety implications associated with on-orbit anomalies, and
- Assure the resolution of safety issues.

2. COMMUNICATION

Communication, the giving or exchanging of information, is the key to success in any endeavor. The setting of an FSR, with a multi-member panel, technical support personnel, and POs, provides multiple opportunities for communication to go awry. Challenges arise from the very setting or medium in which the interaction takes place, the participants involved in the discussion, and the details of the topic discussed that set the frame work for a definitive conclusion [3].

Within the scope of Payload Safety, the following observations have been made regarding past experiences and coordination of daily work and ideas for future planning.

2.1. Observations from the Past and Daily Workings

The way we communicate and the frequency of our correspondence can strongly affect how effectively business will get done. The goals of Safety are so important that it is necessary we stay of one accord within our own organization and in our partnerships.

Working with the PSRP and Support Personnel

Our unified mission is the assurance that the vehicle (for example: Space Shuttle or ISS, etc.) and crew are safe from hazards created by payloads and interactions with the environments and other hardware/experiments operating in the vicinity. Between the PSRP and PSRP support personnel there is an established ease in communication, developed due to the frequency of discussions amongst personnel with common goals. Though it may be on an as-needed basis, there is ample opportunity to contact the necessary technical experts (or subject-matter points of contact) within NASA when issues need to be resolved.

Call for comments, inputs, and technical assessment for distributed payload Safety Data Packages (SDPs) can be garnered by electronic mail (email) or phone call. Electronic correspondence proves to be the most reliable in confirming messages have been sent and received, and is useful for tracking purposes. The present practices of establishing telephone conferences (teleconferences or telecons) or face to face Working Groups (WGs) helps to resolve technically specific issues in a majority of instances and prepare for the FSR. In preparing for the FSR, it truly is a team effort with the PSRP, its support personnel, and the PO. This may include internally interfacing with other NASA Safety Panels (i.e. NASA's Safety Review Panel (SRP) which focuses on ISS systems hardware). In a similar way, Payload Developers (PDs) and POs must be accessible when preparing for scheduled FSRs.

Within the contractor team of PSEs and administrative support, a weekly meeting is held to focus on the latest payload issues and forward plans for resolution. This open forum allows for PSEs to learn from each other and gain insight in how an issue is/was resolved if they are in a similar situation and receive feedback from other engineers on another resolution. Prior to the weekly internal Payload Safety meetings, the engineers should have a clear understanding on what the issue is, how the issue came about (via violation of a requirement, process escape, etc) and a recommendation for a resolution. This type of internal coordination allows for a more efficient means of communication and eliminates multiple discussions on the same issue. Utilizing the experience within the group, PSEs also benefit from the knowledge acquired by other more experienced engineers when they deal with an International Partner (IP) for the first time.

Working with International Partners (IPs)

In order to effectively review and resolve technical concerns within ISS Program, engineers and support personnel must take into consideration and prepare for potential cultural and language barriers. Working with

IPs also means taking into consideration differences in time zones. NASA and the PSRP have addressed these challenges through cultural training classes, interpreters, and adjusting meeting times.

Formats have been created to address technical and administrative concerns with IPs on bilateral and multilateral bases. A good example of an established bilateral format is the Joint American/Russian Safety Working Group (JARSWG), intended to provide support to the ISS for resolution of S&MA issues and facilitate the transfer of information, data and products [4]. There are weekly teleconferences held between NASA and Russia's Rocket Space Corporation-Energia (RSC-E) and periodic face to face week-long meetings. The meetings have proven to be instrumental in facilitating concurrence between the two IPs and sets the tasks to be accomplished in preparation for flight. Many of the discussions open a dialogue which will translate into further email and data transmittals. It is interesting to note that the agreed-upon format for official NASA-to-RSC-E correspondence is the facsimile (fax), a technology used to transfer copies of documents, using equipment operating over a telephone network. A lesson to be learned from this practice is that the ISS community has made compromises to align with the most convenient communication method/s for each IP. Payload Safety and the PSRP performs a majority of their work through email, but finds no issue in meeting the request of the fax format to get work done. The positive results seen through the bilateral JARSWG are numerous.

Another opportunity that has been developed with the IPs is the Franchising of NASA's PSRP. This bilateral arrangement has provided an opportunity to further develop relationships between NASA and NASA Partners, share knowledge of safety with the international community, and streamline processing so PDs and POs have the option of going through their IP-franchised PSRP instead of only through the NASA PSRP. With the ESA PSRP Charter signed in July 2002 [5], NASA and ESA worked together closely through a step-wise development process that took shape over the course of five years [5][6]. The ESA-based PSRP franchise was granted autonomy to perform FSRs in March 2007.

In order to maintain consistency and connection between the NASA PSRP and ESA franchised PSRP, weekly telecons were initiated in June 2008. The telecons provide an opportunity to exchange concerns or provide unique support from one IP to the other on payload-specific issues, generic technical issues, and statusing of payload readiness in preparation for various flight readiness reviews. The weekly meetings with ESA became a key factor in helping to facilitate and ensure that NASA and ESA and their technical experts came together to address issues and to develop future work plans associated with a recent plasma emitting payload. As the relations between the two PSRPs expand, this forum will continue to allow both panels to address urgent and long-range issues in an informal manner.

In addition to bilateral discussions, the PSRP schedules a monthly internal meeting with representatives from each IP invited to participate. NASA S&MA also has a Multilateral S&MA Panel (MSMAP) that addresses topics with all the IPs. The MSMAP conducts monthly telecons and routine face to face meetings.

Preparing for Flight and On-Orbit Situations

Without good information, the chances for resolution in our endeavors are significantly disadvantaged. As the numbers of payloads flying has increased, Payload Safety has been able to expand lines of communication and enlisted the help of NASA's Payloads Office (OZ), and ISS Payload Integration Safety. With the help of these organizations, PS has been able to stay more current on late manifested payloads and can better coordinate with the IPs or POs on deliverables. This also helps the PSRP and PSEs address the increased frequency of emails and phone calls inquiring as to the completeness of payload hardware and verification closures as the flight preparation timeline drops off.

For monitoring of activities during flight and on-orbit, the Safety Consoles at the various Mission Control Centers are the first to know about payloads operational activities that take place on ISS. As the number of International Modules increase, there is a need for solid communication between the IP Consoles to assure that operational issues are discussed real-time. There is also need to have direct access to the PSRP to resolve real-time issues and preserve a safe environment for crewmembers on orbit.

The PSRP and PSEs maintain contact with the ISS Safety Console and track payload activities through daily reports sent out from the Payloads Operations Integration Center (POIC) at NASA's Marshall Space Flight Center (MSFC). The daily reports or record of daily activity is an update each day of an agenda of operations to be conducted aboard the ISS for the week. The ESA Safety Console also provides a report that identifies the tasks taking place within the COL. Our goal is to be more aware of these items from both POIC and ESA. It is anticipated that a similar deliverable will be provided by our JAXA counterparts in the future.

2.2. Future Planning

As Payload Safety moves into the next phase of business, the expectations for communication will stabilize internally and increase internationally. With the retirement of the Shuttle, the next generation of payloads will travel primarily onboard the Russian vehicles, Soyuz and Progress, as well as ESA's Automated Transfer Vehicle (ATV), JAXA's H-II Transfer Vehicle (HTV), and perhaps some commercial carriers. Samples collected will need to return, and items with expiring certification will need to be returned, extended, or discarded. These considerations will significantly challenge and no doubt increase the work performed by Payload Safety participants.

As new safety requirements are derived within Payload Safety for the next generation of NASA Crew Exploration Vehicles, the need for the PSRP support to learn from one another is one of the keys to successful safety assessments. Thus, we have an ever increasing obligation to stay connected. The rising utilization of Blackberry® phones, Personal Data Assistants (PDAs), and laptops keep us connected even outside of our offices, and keeps priorities in order. One recommendation regarding the availability of data would be for each IP to establish data exchange servers to hold larger files, with passwords to allow access to persons who need to download the information. This will provide critical access that can't always be readily captured by telephone, fax, or email.

As the ESA Franchise continues its autonomous operations it will be pulling away from NASA tutelage. The PSRP hopes to extend a franchise to JAXA and will require the same sensitivity in establishing the needed foundation and technical support. These efforts require increased demands on communication, with sensitivity to cultural differences. Counterparts on both sides will be given an opportunity to focus on instituting Memorandums of Agreement (MOAs) across technical disciplines. These will require the technical experts to develop a working rapport and commonality of technical approach to assure payloads receive similar treatment from one franchise to the next. The goal of the PSRP Franchise-to-Franchise interchangeability will easily wither without frequent communications. Whereas ESA will see their biggest interactions through familiarity meetings and annual audits, JAXA will receive more attention focused on franchise establishment, and MOA development. It is vitally important that the entire Payload Safety community maintains close and frequent communications in order to avoid evolving into widely divergent (and possibly conflicting) processes from one country to the next.

3. SAFETY REQUIREMENTS

NASA and Programs within NASA have established Requirements intended to minimize risk and eliminate the probability of a hazardous condition occurring. The SSP and ISS Program Safety Policy is to maintain assurance of a safe operation while minimizing Program involvement in the design process of the payload [7]. Implementation of the Payload Safety Process is a joint responsibility between the PO, PSRP, and vehicle owner. The PO is responsible to assure the safety of its payload and implement the requirements; the PSRP and vehicle owner are responsible to review submitted payload SDPs and assess experiment design, transport and operation [2] [7].

The Safety Requirements utilized by the PSRP and referenced within this paper are listed here; however, there are numerous additional requirements referenced within these documents that are also relevant and applied to payloads.

- NSTS/ISS 13830 (Revision C) *Payload Safety Review and Data Submittal Requirements for Payloads Using the Space Shuttle and International Space Station* (current change number) [2],
- NSTS 1700.7B *Safety Policy and Requirements For Payloads Using the Space Transportation System*(current change number) [7], and
- NSTS 1700.7B ISS Addendum *Safety Policy and Requirements For Payloads Using the International Space Station* (current change number) [8].

3.1. Observations from the Past and Daily Workings

The initial authors of the Payload Safety Requirements wanted to craft a set of requirements that would be applicable to all items from the most complex deployable satellite to the simplest passive bag of tomato seeds. The requirements are, therefore, broad in scope and provide little detail.

To have gone to great specificity would have required a soothsaying ability that is impossible. It would also have resulted in a requirements document that rivaled the Payload-to-Shuttle Interface Control Document (ICD) (a detailed document well over 1000 pages) and would have been a burdensome duplication of effort for the payload developers that would have quashed most of the basic or low budget experimenters/payloads that are conducted on Shuttle and ISS.

Interpreting Requirements

A logical consequence of establishing an intentionally imprecise set of requirements was that the most efficient path to follow in order to demonstrate compliance was not obvious in many cases. To remedy this, the PSRP began the practice of documenting acceptance rationale

and applications for safety requirements in requirements interpretation letters. These letters, signed by either the technical experts or program management, infuse a certain amount of engineering judgment to prevent a "one-size fits all" review standard and are collected in NSTS/ISS 18798 Revision B *Interpretations of NSTS/ISS Payload Safety Requirements* [9].

The interpretation letters are called upon by POs to determine how best to apply requirements and to verify appropriate controls to hazards and are, consequently, documented in the applicable requirements section of a hazard report. The letters are also considered by the PSRP and all reviewers of the payload's hazard analysis, especially the technical experts. In many ways, the interpretations letters serve as reminders and capture the essential knowledge behind the requirements similar to the rationale statements provided in flight rules. Subjects addressed within interpretation letters include the following [9]:

- Protection of Payload Electrical Power Circuits,
- On-Orbit Bonding and Grounding,
- Crew Mating/Demating of Powered Connectors,
- Mechanical Systems Safety, and
- Safety Policy for Detecting Payload Design Errors.

Maintaining Requirements

As the Space Shuttle and ISS Programs have grown, the knowledge of vehicles and the microgravity environment have also grown. In order to maintain alignment of safety requirements with current knowledge, document-specific Change Requests (CRs) have been developed.

Over the years, the PSRP and its technical support personnel have initiated, developed, and processed CRs to the three documents noted in Section 3.0 of this paper for the following reasons:

- The current requirement is out-dated due to advances in engineering standards,
- A new or previously un-known hazard is discovered, and
- Changes in the Space Shuttle or ISS Programs dictate changes that should be made to the requirements (Program directive).

Before obtaining approval of the requested change, the change and supporting rationale are presented to multiple Program panels and boards, allowing for input from NASA Programs and, when applicable, the IPs. While the collective time required to process a CR can be large, maintaining the requirements tends to outweigh the time factor.

3.2. Future Planning

In looking forward to the post-Shuttle era, there are many changes that NASA needs to implement in the Safety Requirements. The PSRP-utilized requirements will reach further than originally drafted. With the development of IP-based PSRP Franchises, new vehicles and sustaining ISS, Payload Safety looks to share our requirements across Programs and agencies. Our vision is that we ultimately ensure continuity of Payload Safety Requirements in the post-shuttle era.

Envisioning "Vision 1700"

With the retirement of the Space Shuttle in 2010, Shuttle specific requirements will become obsolete. This poses a problem for the PSRP requirements as the NSTS 1700.7B and NSTS 1700.7B ISS Addendum are currently laid out. The current structure of these requirements documents are such that the ISS Addendum references back to the NSTS 1700.7B parent document [7]. The PSRP's plan to address the ISS Safety Requirements has been deemed "Vision 1700" The proposed plan would merge the NSTS 1700.7B and ISS Addendum [8] into one document, with the proposed document designation of SSP 51700.7, for ISS payloads only [10]. Pointers to Shuttle specific requirements will be removed and launch vehicle safety requirements will only be mentioned as reference points. The launch vehicle owners (NASA's Space Shuttle, ESA's ATV, JAXA's HTV, and Russia's Soyuz and Progress) would continue maintaining their own launch vehicle safety requirements.

The perceived benefits of this plan include eliminating the need to refer to safety requirements embedded in Shuttle documents when launching on other vehicles. This will create a roadmap with pointers to payload safety requirements across mission phases (launch, on-orbit operations, and return).

The first steps involve the restructuring of the ISS safety requirements document, NSTS 1700.7B ISS Addendum, to allow a direct integration of Shuttle safety requirements and ISS safety requirements. Then, comments will be solicited from the PSRP community to be incorporated into a CR. The CR will include all previous changes made to NSTS 1700.7B and remove the Shuttle-based requirements that apply to the payload's transport phase. The CR will then be distributed to the Multi-lateral community for a unified position on the direction of the document.

Integrating all IP requirements and generating a truly international document will allow all parties to remain cognizant in ensuring the safety of the ISS program.

4. PROCESSES

Payload Safety Processes, the particular method of reviewing payloads for flight, generally involves a number of steps or operations. The PSRP operates under the general premise of receiving payload SDPs and reviewing payload SDPs; however, within this foundation there are many specific and detailed processes that can become applicable to the Payload Safety Process.

To address Payload Safety Processes within this paper, past and daily workings are combined with future thoughts under each Process identified here.

4.1. Process timelines for SDPs in support of an FSR

In NSTS/ISS 13830 Paragraph 4.3.1 Data Submittals [2], the requirement is as follows:

> "Safety review meetings are scheduled to be held approximately 45 calendar days after receipt of an acceptable SDP (i.e., an SDP that satisfies all the requirements in this document)."

Payloads and experiments require months if not years of planning, design, manufacturing, testing, and preparation for launch. Though 45 days seems like a long time for a review of a data package, the sheer quantity of work that flows through the PSRP for each payload requires that we have a set time to conduct a thorough review to assure that the safety of the manned space program is maintained.

The following provides an insight into the activity that goes on with the PSRP to provide insight about the 45 days.

- Upon receipt of the SDP, three days for administrative review is conducted to check the level of completeness of the package per submittal requirements,
- Dependent on the schedule this administrative review is followed by four weeks for technical review (28 days). This includes distribution of the package to technical support and comments from that support to be submitted at deadline to the associated PSE, and
- A two week (14 days) period follows the comment deadline in which the comments are worked with the Payload Organization for clarification (3+28+14 = 45 days).

The last two weeks can be very important. After the comments are provided by the technical reviewers, the PSE compiles the comments and provides them to the PO. This allows the PO to assess the types of questions that can be expected at the review. It is very desirable that the PO provide a response to the comments and communicate with the PSE to determine if a WG is required to better understand and/or explain specific areas of concern in preparation for the FSR. This alleviates extensive and repetitive discussions during the FSR and allows for a more efficient review. If updates are made to the SDP at any point from submittal of the SDP, the PO should document these changes and make that information available to the PSRP prior to the FSR.

4.2. Panel Workload and Scheduling of Reviews

The PSRP reviewed 449 SDPs in FY08 which equates to 8.6 SDPs per week. The same personnel that provide comments routinely sit in on the formal FSRs to discuss comments and guide the PSRP and POs to consensus on safety for their given areas of expertise. In FY08, the PSRP held 158 Formal FSRs, which equates to three FSRs per week. Not all reviews take the entire day, but by the same measure, some are multiple day reviews. Scheduling of reviews can seem somewhat capricious to PDs, since the first payload package in for a review is not necessarily the first one reviewed. The PSRP assigns priority based on manifested flight, hardware shipping status, complexity of payload, and other considerations dictated by Programs the PSRP supports. With POs continually submitting data outside of the 45 day requirement and requesting an expedited review to meet launch or shipping schedules, the PSRP schedule becomes overloaded and the Panel runs the risk of becoming less effective. A short turn-around for a package increases the safety risk in that there is inadequate time to review all the necessary hazards. Payload Safety has taken the initiative to coordinate with POs for data submittals once a Change Evaluation Form (CEF) is submitted to the Manifest Working Group. Ideally, this should allow for an SDP submittal closer to the 45 day requirement and a more adequate review by the PSRP.

4.3. Readiness Reviews

The general business of space flight requires communication and attention to status by the NASA Space Shuttle and ISS Program Offices as well as those of our IPs that are supporting ISS by the launch of their vehicles. Flight support meetings include the Safety and Mission Success Reviews (SMSRs), Stage Operation Readiness Reviews (SORRs), Safety and Mission Assurance Panels (SMAPs) and Program Requirements Control Boards (PRCBs), to name the most common program meetings. These are required for providing status and readiness information to the Program and IP management who have a vested interest in the sustained support of the ISS. Preparation and support of these meetings require hundreds of man hours per flight by the PSRP to assure that safety information is provided to support each payload that is launched or returned. The main thrust of the Flight Support Meetings is providing the Certificate of Flight

Readiness (CoFR) status. The CoFR process requires constant attention and weekly updates for the last 90 days prior to launch. ESA PSRP is responsible for providing input to the PSRP CoFR for ESA PSRP-reviewed payloads. All IPs provide their CoFR endorsements for their respective segments to the ISS Program Manager.

4.4. Payload Anomaly Reporting and Documentation

Regardless of how well hardware is designed and the operations plan is prepared, anomalies may occur. Despite the cause of an anomaly, scientists and engineers have a duty to record the deviation and determine any planning or design change that would have kept this from occurring. Documenting anomalies becomes a historical database that serves many purposes, including determination of systemic causes, recurrent failures, need for improved materials and/or processes, etc. A properly written Anomaly Report (AR) could identify technical design issues, improper assembly, packaging, handling, transportation and stowage issues or even break down in communication between testing and design. The purpose of this section is to identify the basic information that should be included in an AR to address safety concerns.

A Payload Anomaly Report (PAR) should contain:

- Definition of the anomaly - to include when and where it occurred, what was going on when the anomaly occurred {shipping, testing, manufacturing/assembly (define), storage, installation (where), launch, translation or on-orbit operations (again define)}, and what was affected (engineering hardware, flight hardware, test fixtures launch vehicle, ISS). It is also useful to note if personnel were injured and include pictures of the affected articles if at all possible.
- Investigation of the anomaly - This is where the PO should establish the root cause and implement a corrective action plan. Assessment of previous PARs could reveal similarities to other failures that have occurred and suggest a reassessment of the effectiveness of previous corrective actions. If this is a unique failure cause, document it accordingly.
- Effects of the anomaly - The PO should address whether the damage and subsequent rework/repair affects any safety controls or render them invalid. If any controls are invalidated, the method to revert to a safe state should be detailed.

Once the PAR has been completed, it should remain with the Hardware Design Documentation/Data Package and be discussed at the next FSR with the PSRP. If the anomaly occurs after the Phase III FSR, either an Anomaly Technical Interchange Meeting (TIM) or Delta FSR may be required based on resultant design changes and/or effects on the applicable Hazard Reports and verifications. The minutes from that meeting will be used to document the acceptability of the report as it pertains to safety impacts (if any).

As individuals intricately involved in the safety process, the PSRP has an obligation to assure that anomalies are sufficiently documented and worked to assure that Space Safety is not compromised.

4.5. Non-Compliance Reports (NCRs) and Accepted Risk Hazard Reports (ARHRs)

The journey to and from Low Earth Orbit and the operations, by definition, are hazardous. The Payload Safety requirements of NSTS 1700.7B were written to require two fault tolerance against any catastrophic (loss of life/vehicle) hazard [7][8]. Where two fault tolerance is not practical (e.g. pressure vessels, structures, etc.), certain “Design for Minimum Risk” factors (materials, construction techniques, etc.) may be employed. Alas, in some cases, compliance with these stringent requirements can not be achieved. In such cases, NSTS/ISS 13830 has detailed several processes to bring the risks associated with such noncompliances in front of Program management for acceptance. The original process developed by the Space Shuttle Program at its outset and used by the ISS Program is the NCR Process. The NCR Process was utilized by the Space Shuttle Program from the beginning through the STS-107 time period. With the Columbia accident, the process was discontinued for the Space Shuttle Program with the same type of information presented to the Program management in the Accepted Risk Hazard Report (ARHR) format. In either case, the risk associated with non-compliance with the Safety Requirements is documented. The change of acceptable documentation formats resulted in a great deal of confusion on the part of POs. This confusion can be avoided by the vigorous employment of process navigators such as Payload Integration Managers (PIMs). The lack of such expertise within the Payload Organization may result in numerous false starts on the way to getting approval for flight.

The PSRP currently supports two Programs which complicate the process when judging the hazard self-assessments performed by the POs, as there are two processes to follow to get NCR approval. Non-compliances that affect both Programs are obligated to proceed through both processes. It should be noted that the Constellation Program is not yet requiring active support from the PSRP, but NSTS 1700.7B and NSTS/ISS 13830 are found in their requirements documents, too.

Space Shuttle ARHR Process: The Shuttle ARHR Process involves stops at many pre-boards on the way to the Program Requirements Control Board (PRCB).

First, naturally, the ARHR is coordinated with the PSRP. After concurrence is reached at the PSRP, the ARHR is next brought to the Shuttle Program's SMAP. At this point, the ARHR may be brought before a special board such as the Extra Vehicular Activity (EVA) Analysis and Integration Team (AIT) if appropriate. This is followed by review and concurrence at the Flight Operations and Integration Control Board (FOICB). If the ARHR is related to an ISS mission, the subsequent review authority is the Joint Mission Integration Control Board (JMICB). Following concurrence there, the ARHR is brought by the PO to the PRCB.

ISS NCR Process: ISS NCRs follow a similar array of meetings. First, the PO brings the NCR to the PSRP. Then the ISS SMAP must concur on the NCR. Then, unless concurrence is necessary from the EVA AIT or the JMICB, the PO may proceed to the Space Station Program Control Board (SSPCB).

5. CONCLUSION

Payload Safety's focus remains on securing the manned flight initiatives that were the basis of the PSRP Charter. There are areas that need continuous attention to assure that our experimental facilities maintain a central theme of safety first, last and always. The road thus far has been a learning experience filled with evolving ideas, and the future suggests a continuation of the same with a more rigorous use of time, people, and money. The building blocks for continued safe payload operations physically exist aboard the ISS and it is up to Payload Safety to balance the challenges of streamlining requirements and processes. Communication, documentation, and procedural development need to be carefully watched and continually nurtured as we move into the increasingly diverse areas of international cooperation in space exploration. Each of our future space exploration goals starts today, and how we view safety will either result in demands to cease as a result of our failures or will keep the public viewing space exploration as exhilarating due to our success.

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Building On The Past-
Looking To the Future:

A Focus on Payload Safety

Scott Wolf
Payload Safety Review Panel Chair

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International Association for the Advancement of Space Safety

Presentation Outline

- Purpose of Paper
- Payload Safety Background
- Communication
- Safety Requirements
- Processes
- Summary/Recommendation
- Contact Information

Purpose of Paper

- Provide a Lessons Learned from a Payload Safety Perspective
- Discuss the Objectives for Payload Safety in the Next Era of Flight Safety
- Promote Effective Communication
- Discuss Future of Payload Safety Requirements
- Encourage the Development of a More Streamlined and Efficient Safety Process

Payload Safety Background

- Chartered by NASA in the 1970s, the Payload Safety Review Panel (PSRP) began conducting reviews of payload flight hardware or Flight Safety Reviews (FSRs) in 1979 in support of the Space Shuttle Program

- Comprised of approximately twelve members representing key NASA Directorates (divisions) and the Space Shuttle and ISS vehicles
  - Interpretation of safety requirements and provide recommendations for implementation and/or interpretation
  - Evaluate modifications to hardware that either affect a safety critical subsystem or create a potential hazard to the vehicle or crew
  - Evaluate safety analyses, safety reports, and non-compliant conditions
  - Assure the resolution of safety issues

- Supports both the Space Shuttle Program and the ISS Program and will be supporting NASA's newest program the Constellation/Exploration Program in the future

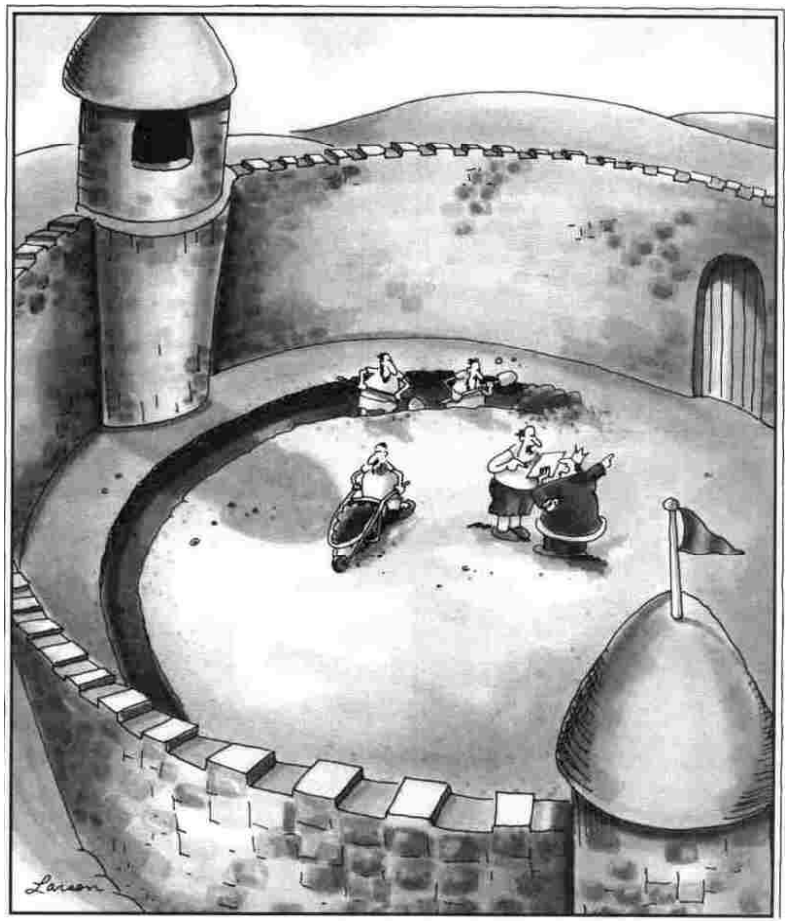
Communication

- Baseball
  - Coach giving signals,
  - 1st Base Coach speaking directly
  - Conference at the mound
- Key Communication
  - Internal PSRP
    - Monthly Internal PSRP Review (IPR)
    - Scheduling
    - Resolution of Technical Concerns
  - Internal NASA
    - Requirement Consistency (Change Requests)
  - External (Payload Organizations and International Partner)
    - Flight Safety Review Preparation
    - JARSWG
    - ESA Franchise

Communication

BREAKDOWN

- Cultural Differences
- Time Zones
- Language Barriers
- Differences in Interpretation
- Frequency and Format



Suddenly, a heated exchange took place between the King and the moat contractor.

Safety Requirements

- **Intentionally Ambiguous Safety Requirements**
  - Interpretation Letters to provide technical detail and assistance on deciphering requirements
- Change Requests
  - To stay up-to-date with current technologies and knowledge base

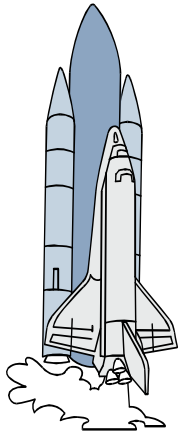
Safety Requirements

- **The "Vision"** 
  - Merge the NSTS 1700.7B and ISS Addendum into one document (Vision 1700)
- **Forward work**
  - Comments will be solicited from the PSRP into a Change Request (CR)
  - Distribute to the Multi-lateral community for a unified position on the direction of the document

Processes

- **Data Submittal**
  - NSTS/ISS 13830 requires that Safety review meetings are scheduled to be held approximately 45 calendar days after receipt of an acceptable Safety Data Package (SDP)

- **Forward work**
  - Encourage POs to adhere to the submittal requirements in an effort to provide a thorough safety review
  - Assign priority based on manifested flight, hardware shipping status, complexity of payload, and other considerations



Processes

- **Payload Anomaly Reports (PARs)**
  - Return Hardware to a Safe Configuration
  - Assessment of the Anomaly
  - Investigation of Root Cause
  - Effects and Safety Implications
- **Forward Work**
  - Proper documentation by PO into a PAR
  - Review PAR with PSRP

Processes

- **Non-Compliances and Risk**
  - Alleviate confusion in navigation through the Non-Compliance Reports (NCRs) and Accepted Risk Hazard Reports (ARHRs) processes
- **Forward work**
  - Assistance of process navigators such as Payload Integration Managers (PIMs) is essential
  - Develop a clear understanding of which process steps will be utilized (Space Shuttle ARHR Process, ISS NCR Process) to achieve closure

Summary/Recommendation

Each of our future space exploration goals starts today, and how we view safety will either result in demands to cease as a result of our failures or will keep the public viewing space exploration as exhilarating due to our success.

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